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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Jet Propulsion Engine Nozzle

We, GENERAL MOTORS CORPORATION, a Company incorporated under the laws of the State of Delaware, in the United States of America, of Grand Boulevard, in the City of Detroit, State of Michigan, in the United States of America (Assignees of CHARLES HOBART SMALE) do hereby declare the invention for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to jet propulsion engine nozzles capable of vectoring, by which is meant jet nozzles capable of varying the direction of a propulsive or lift jet.

The preferred embodiment of the invention is intended for application to lift engines in which the axis of the engine is vertical and the nozzle may be actuated to deflect the jet either forward or backward or to either side for manoeuvring the aircraft or to control aircraft jaw.

Preferably, the nozzle is of a convergent type, but it is applicable to divergent nozzles and to nozzles for engines for purpose other than direct lift.

The principal object of the invention is to improve the performance of vertical lift engines. Another object is to render available a simple easily controlled nozzle vectorable about two crossed axes.

The scope of the invention is defined by the appended claims; how the invention may be performed is particularly described below with reference to the accompanying drawings, in which:—

Figure 1 is a partial elevation view of a lift jet engine including a deflecting nozzle according to the invention;

Figure 2 is a bottom view of the same;

Figure 3 is an elevation view corresponding to Figure 1 with the nozzle operated to deflect the jet to provide forward thrust;

Figure 4 is a view on a plane at right angles to that of Figure 3 showing the nozzle deflected to provide lateral thrust;

Figure 5 is a fragmentary sectional view taken on the plane indicated by the line 5—5 in Figure 4 showing the inter-connection between the main and corner leaves; and

Figure 6 is an oblique view of the nozzle.

Referring first to Figures 1 and 6, the jet deflecting nozzle is shown as attached to the lower or exhaust end of a reaction engine E, which may be a lift turbojet or turbofan engine. A jet pipe 9 provides a transition from circular to rectangular section and terminates in a rectangular outlet 10 which is preferably square. Four main jet deflecting flaps 11 are mounted at the end of the jet pipe, one at each side, the flaps being pivotably mounted by hinges 13. The flaps are of trapezoidal form, having edges 14 converging in the direction away from the hinge. An actuating arm 15 extending from each leaf 11 is coupled to the piston rod 17 of an actuating cylinder 18 suitably anchored by means (not illustrated) to the engine so that the flap 11 may be swung inwardly or outwardly by the cylinder 18. Each main flap is coupled to an individual actuating cylinder. The flaps 11 are of a light weight cellular double-walled construction, as illustrated in Figure 5, comprising an outer sheet 19, an inner sheet 20, and cellular or honeycomb material 21 filling the space between and bonded to the sheets.

There is, of course, a wide gap between the edges 14 of adjacent main leaves. The enclosure of the rectangular nozzle is completed by four corner closure members 24, one at each corner of the nozzle, each corner closure member comprising two corner flaps 25 connected by a corner hinge 26. Each corner hinge includes a hinge pin terminating in a head 27 which has an opening universally connected to the jet pipe 9 by a ball-headed stud 29 extending from the jet pipe. The corner flaps lie against the outer face of the main flaps 11 and, in effect, constitute variable extensions of the side edges of the main flaps 11. Like the main flaps, the corner flaps are of double-walled structure as shown in Figure 5, comprising outer and inner sheets and a honeycomb bridging the space between the sheets.

The corner flaps are coupled to the main flaps so as to allow the former, to pivot about an axis at each upper corner of the main flap perpendicular to the plane of the main flap. The main and corner flaps are connected by rollers operating in tracks on the corner flaps so that this extension and retraction of the corner flaps may take place with a minimum of friction. The corner flap is made in two parts, an upper and a lower part, which are joined together by an arcuate track piece 35 (Figures 1 and 5) strengthened by gussets or stiffeners 36. The track piece has double-flanged edge portions 37 and 38, the two flanges of which are welded or brazed to the outer and inner walls of the corner flap. One portion of the track piece forms a track 39 which receives a roller 41 rotatably mounted on a boss 42 extending from the main flap 11. The track piece also forms a second track 43 which co-operates with two rollers 44 rotatably mounted on angled bosses 45 extending from the main flap 11. The rollers are in position to engage both faces of the tracks, which extend on both sides of the rollers; thus a restraint is provided between the main and corner flaps in both the direction axially of the nozzle and that radially of the nozzle.

The mode of operation of the nozzle should be clear but will be described briefly. As shown in Figures 1 and 2, the nozzle is in what may be considered the normal slightly convergent centered configuration, with no deflection of the jet. The angle of all of flaps 11 to the axis of the nozzle is the same. In Figure 3, which is a side view, the forward main flap 11 has been deflected rearwardly and the rear main flap 11 has likewise been deflected rearwardly so that the jet will issue from the nozzle with a substantial rearward component of motion to provide forward thrust on the airframe in addition to the lift. Figure 4 is a rear view of the engine in which the right-hand main flap has been moved toward the nozzle axis and the left-hand main flap away from the axis, so that the engine thrust has substantial component to the left for movement of the aircraft to the right, or yawing of the aircraft by co-operation of two such engines with the thrust oppositely deflected.

With the structure shown, it is possible to open the nozzle into a divergent configuration, putting the throat at the hinge line rather than the exit of the nozzle. However, in the preferred embodiment as a lift engine nozzle such operation is not contemplated. The structural arrangement of main and corner flaps is adaptable to polygonal nozzles of three or more sides, but a rectangular nozzle is preferred. Preferably, the nozzle outlet area is maintained constant during vectoring, but it can be varied if desired. Any suitable control can be used to co-ordinate the flap actuators as desired.

WHAT WE CLAIM IS:—

1. A nozzle for a jet propulsion engine operable to deflect the jet comprising the following combination:— a jet pipe having a polygonal outlet the three or more sides of which extend downstream from a common hinge plane; each side comprising a main flap hinged to one side of the jet pipe at the said plane, the main flaps being of trapezoidal form with edges converging in the direction away from the hinge, and a corner flap at each said edge of each main flap extending substantially in the plane of the corresponding main flap; a connection of each corner flap to the corresponding main flap for pivoting about an axis perpendicular to the main flap at the adjacent end of the hinged side of the leaf and maintaining the corner leaf parallel to the corresponding main leaf; and a hinged connection between the two corner flaps at each corner defined by the bounding sides of the jet pipe outlet; the main and corner flaps thus forming a nozzle of polygonal cross section with all bounding sides pivotable to deflect the jet and there being actuator means effective to pivot each main flap about its hinge axis.

2. A nozzle as recited in claim 1 in which the nozzle is rectangular.

3. A nozzle as recited in claim 1 in which the connection of each corner flap to the main flap comprises track means on one flap and roller means on the other flap engaging the track means.

4. A nozzle as recited in claim 3 in which the track means includes two tracks and the roller means includes rollers engaging each track; one track and roller set having the roller axis at right angles to that of the other set.

5. A jet propulsion engine nozzle, substantially as hereinbefore particularly described with reference to, and as shown in, the accompanying drawings.

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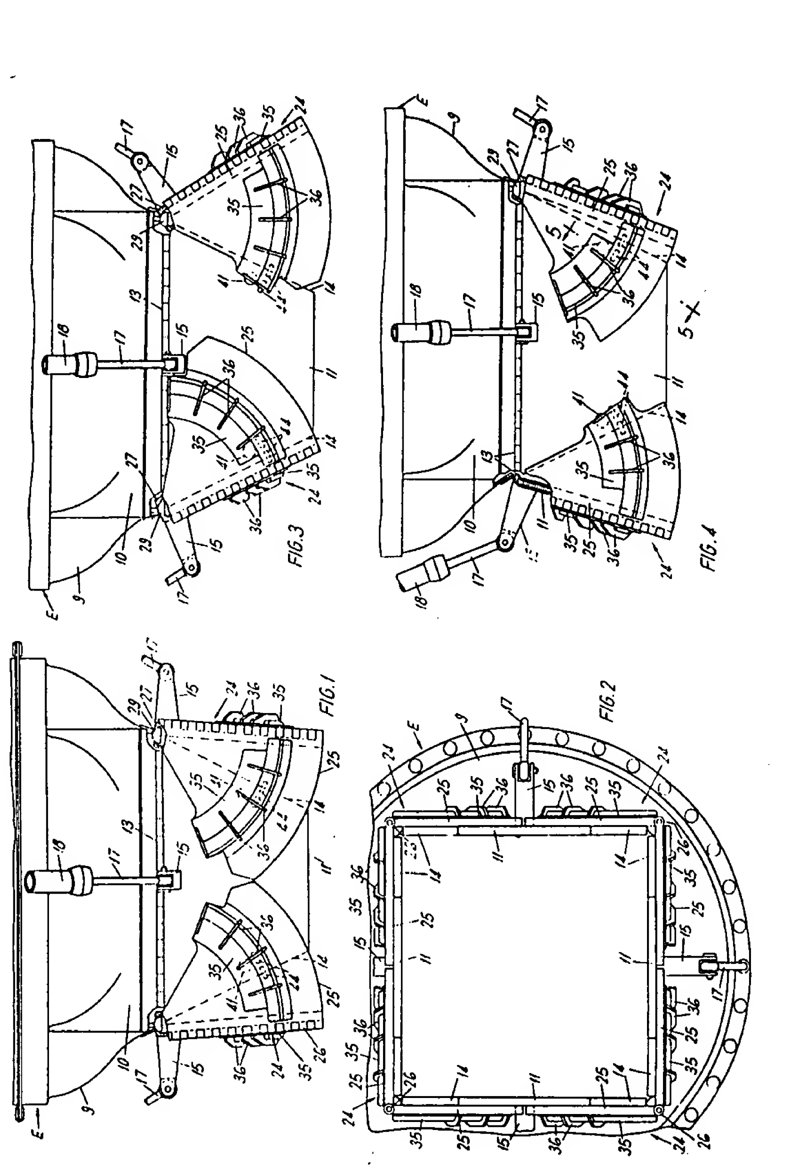

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2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

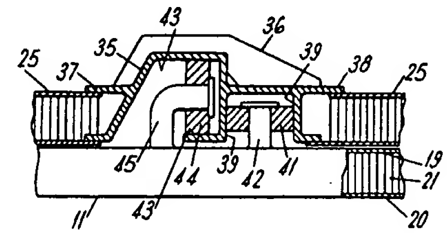

FIG.5

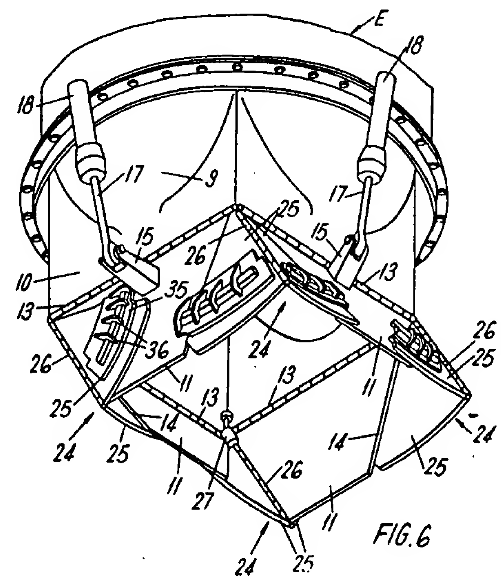

FIG.6